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An optimized protocol for acoustic impedance measurements: „Simultaneous multi component multi frequency tympanometry“

Introduction

The most common probe tone frequency used in tympanometry is 226 Hz. Using 226 Hz, well known and categorized tympanogram shapes can be obtained, especially in adult patients. When testing infants younger than four months, a probe tone frequency in the range 660-1000 Hz is recommended (Baldwin et al., 2000). In many cases though, the optimal probe tone frequency is not a well established value. Multi frequency tympanometry is said to improve on middle ear diagnostics (e.g. Hunter and Margolis, 1992). In practice however, the “standard” measurement is performed in the majority of cases.

The goal of the present study is to examine whether it is possible to record multiple tympanograms at once when presenting multiple probe tones at the same time.
This would allow to perform multi frequency tympanometry without increasing test duration.

Method

Tympanograms were recorded from 22 ears (of 11 adults). Five measurements were performed in a series. The test frequency was 226 Hz, 678 Hz, 800 Hz, and 1000 Hz for measurements one to four. For the last measurement, all four tones were presented simultaneously. The pressure range was -200 to 200 daPa (descending) for all measurements.

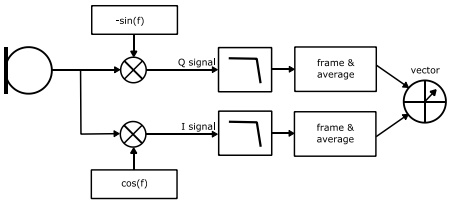

Fig 1: Parallel signal processing: For each probe tone, a heterodyne filter is used to calculate real and imaginary part of the microphone sound pressure. In a second step, these are transformed to admittance components susceptance and conductance.

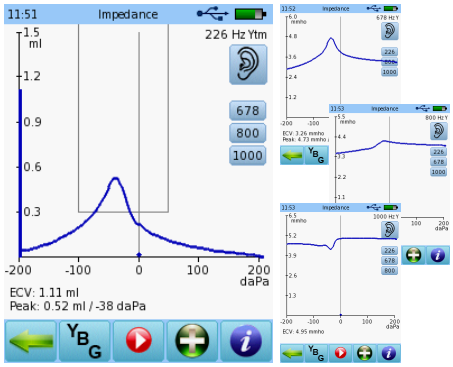

Fig 2: Measurement UI on the mobile device (Sentiero Desktop)

Measure	Difference (abs.)	Diff. %
Admittance Y	-0.05 ± 0.07 mmho	1.5
Susceptance B	-0.04 ± 0.06 mmho	1.3
Conductance G	-0.04 ± 0.06 mmho	3.6
Peak (226 Hz)	1.5 ± 2.7 daPa -0.01 ± 0.09 mmho	-- 0.7
TW (226 Hz)	-3.3 ± 8 daPa	3.9
ECV (226 Hz)	-0.04 ± 0.03 mmho	2.9

Tab 1: Differences between conventional and multi frequency recordings

Results

The average difference in admittance over the complete pressure range amounted to -0.05 ± 0.07 mmho (which is about 1.5% of the total amplitude). The other measures show similar deviations (see table 1). The peak of the 226 Hz tympanogram was shifted by 1.5 daPa on the horizontal axis and 0.01 mmho on the vertical axis on average.

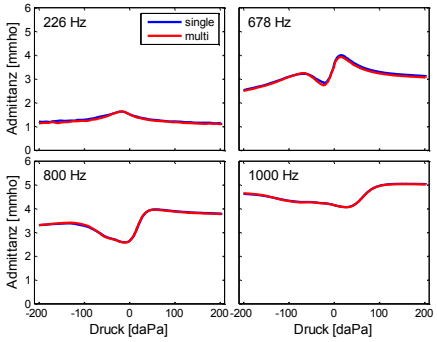

Fig 3: Comparison of multi frequency and single frequency tympanograms

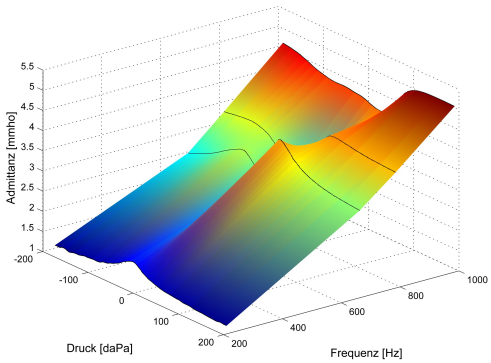

Fig 4: Multi frequency „3D-Tymp“

Discussion

Multi frequency tympanograms show little difference to tympanograms that are recorded with a single probe tone. These differences are within the expected test retest stability of tympanometry (Carazo and Sun, 2014; Wiley and Barrett, 1991) and within the accuracy limits of immittance instruments standards (IEC 60645-5).
Tympanograms can be recorded for multiple probe tones at the same time, without influencing test results and without increasing test time. Compared to conventional tympanometry, multi frequency tympanometry can be performed without additional effort.

Literature: ▪ Baldwin M, Brooks D, Gravel J, Thornton R (2000) Neonatal hearing screening and assessment. Tympanometry in neonates and infants under 4 months: A recommended test protocol. ▪ Hunter LL, Margolis RH (1992) Multifrequency tympanometry: Current clinical application. Am J Audiol 1, 33-43. ▪ Carazo CD, Sun XM (2014) Effects of consecutive trials and test-retest reliability of 1000-Hz tympanometry in adults. Int J Audiol. 2014 Sep 29:1-8 ▪ Wiley TL, Barrett KA (1991) Test-retest reliability in tympanometry. J Speech Hear Res. 1991 Oct;34(5):1197-206.